

CLAIMS

We claim:

- 1 1. Semiconductor chip which emits electromagnetic radiation, having
 - 2 - an epitaxially produced semiconductor layer stack (1) based on nitride semiconductor
 - 3 material, which includes an n-conducting semiconductor layer (11), a p-conducting
 - 4 semiconductor layer (13) and an electromagnetic radiation generating region (12) which is
 - 5 arranged between these two semiconductor layers (11, 13),
 - 6 - a base (50), on which the semiconductor layer stack (1) is arranged, and
 - 7 - a mirror layer (40), which is arranged between the semiconductor layer stack (1) and the
 - 8 base (50) and reflects electromagnetic radiation emitted by the semiconductor layer stack (1) in
 - 9 the direction of the base (50),
 - 10 characterized in that
 - 11 - the mirror layer (40) has a plurality of planar reflection sub-surfaces (14), which are
 - 12 positioned obliquely with respect to a main plane of the radiation-generating region (12) and
 - 13 each form an angle of between 10° and 50° with this plane.
- 1 2. Semiconductor chip according to Claim 1, characterized in that the p-conducting
 - 2 semiconductor layer (13) faces the base, and the mirror layer (40) is formed by means of a
 - 3 reflection surface (131) of the p-conducting semiconductor layer (13), which includes a plurality
 - 4 of planar sub-surfaces (14) which are positioned obliquely with respect to a main plane of the
 - 5 radiation-generating region (12) and each form an angle of between 10° and 50° with this plane.

1 3. Semiconductor chip which emits electromagnetic radiation, having
2 - an epitaxially produced semiconductor layer stack (1) based on nitride semiconductor
3 material, which includes an n-conducting semiconductor layer (11), a p-conducting
4 semiconductor layer (13) and an electromagnetic radiation generating region (12) which is
5 arranged between these two semiconductor layers (11, 13),
6 - a base (50), on which the semiconductor layer stack (1) is arranged, and
7 - a mirror layer (40), which is arranged between the semiconductor layer stack (1) and the
8 base (50)
9 characterized in that
10 - the n-conducting semiconductor layer (11) faces away from the base, and
11 - the n-conducting semiconductor layer (11) or an outcoupling layer (16) located on the n-
12 conducting semiconductor layer (11) has a radiation-outcoupling surface (111) which in turn
13 includes a plurality of planar outcoupling sub-surfaces (14) which are positioned obliquely with
14 respect to a main plane of the radiation-generating region (12) and each form an angle of
15 between 15° and 70° with this plane.

1 4. Semiconductor chip which emits electromagnetic radiation according to Claim 2, in
2 which an outcoupling layer (16) is arranged at least partly on the n-conducting semiconductor
3 layer (11).

1 5. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the n-conducting semiconductor layer (11) or an outcoupling layer (16) located on the n-

3 conducting semiconductor layer (11) has a radiation-outcoupling surface (111) which in turn
4 includes a plurality of planar outcoupling sub-surfaces (14) which are positioned obliquely with
5 respect to a main plane of the radiation-generating region (12) and each form an angle of
6 between 15° and 70° with this plane.

1 6. Semiconductor chip which emits electromagnetic radiation according to Claim 5, in
2 which the reflection sub-surfaces (14) or the outcoupling sub-surfaces (14) form pyramid-like
3 structures (15).

1 7. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the mirror layer (40) includes a plurality of different layers.

1 8. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the mirror layer (40) comprises
3 - a highly reflective layer (41), and/or
4 - a protective layer (42), and/or
5 - a joining layer (43).

1 9. Semiconductor chip which emits electromagnetic radiation according to Claim 8, in
2 which the highly reflective layer (41) contains silver or aluminium.

1 10. Semiconductor chip which emits electromagnetic radiation according to Claim 8, in
2 which the protective layer (42) contains titanium nitride.

1 11. Semiconductor chip which emits electromagnetic radiation according to Claim 8, in
2 which the joining layer (43) contains gold, tin and/or an alloy of these metals.

1 12. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which an outcoupling layer (16) located on the n-conducting semiconductor layer (11) contains
3 SiC or consists of SiC.

1 13. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the semiconductor layer stack (1) includes at least one trench (17) which defines a
3 plurality of individual semiconductor layer elements (18).

1 14. Semiconductor chip which emits electromagnetic radiation according to Claim 11, in
2 which a plurality of trenches (17) are provided, extending in such a manner that the
3 semiconductor layer elements (18), in plan view, are in the shape of a circle, a hexagon, a
4 quadrilateral, a triangle or a combination of these shapes.

1 15. Semiconductor chip which emits electromagnetic radiation according to Claim 14, in
2 which the semiconductor layer elements (18) each have a diameter or a width which includes at
3 most ten pyramid-like structures (15).

1 16. Semiconductor chip which emits electromagnetic radiation according to Claim 14, in
2 which the trench(es) (17) are at least sufficiently deep for them to isolate at least the radiation-
3 generating region (12).

1 17. Semiconductor chip which emits electromagnetic radiation according to Claim 14, in
2 which the width of the trench (17) or trenches (17) is at least double the depth of the trenches.

1 18. Semiconductor chip which emits electromagnetic radiation according to Claim 14, in
2 which the trench(es) (17) are filled with an electrically insulating material (19) which transmits
3 radiation generated by the radiation-generating region (12).

1 19. Semiconductor chip which emits electromagnetic radiation according to claim 1, in which
2 a radiation-transmitting electrically conductive contact layer (2) is arranged on the n-conducting
3 semiconductor layer (11).

1 20. Semiconductor chip which emits electromagnetic radiation according to Claim 19, in
2 which the contact layer (2) contains indium tin oxide and/or ZnO.

1 21. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the semiconductor chip is a thin-film component, from which a growth substrate wafer

3 (10) is at least partially removed after the epitaxially produced semiconductor layer stack (1) has
4 been grown.

1 22. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the p-conducting semiconductor layer (13) is doped with magnesium.

1 23. Semiconductor chip which emits electromagnetic radiation according to Claim 1, in
2 which the base (50) contains gallium arsenide or copper.

1 24. Method for fabricating a plurality of semiconductor chips which emit electromagnetic
2 radiation, comprising the following method steps:
3 a) provision of a growth substrate wafer (10),
4 (b) epitaxial growth of a semiconductor layer sequence on the growth substrate wafer (10),
5 which includes a p-conducting semiconductor layer (13), an n-conducting semiconductor layer
6 (11) and an electromagnetic radiation generating region (12) which is arranged between these
7 two semiconductor layers (11, 13), the n-conducting semiconductor layer (11) being first of all
8 grown on the growth substrate wafer (10), and a plurality of planar sub-surfaces (14), which are
9 positioned obliquely with respect to a main plane of the radiation-generating region (12) and
10 each form an angle of between 10° and 50° with this plane, being formed on the p-conducting
11 semiconductor layer surface,
12 (c) application of a mirror layer (40) to the p-conducting semiconductor layer (13),
13 (d) production or application of a base (50) on or to the mirror layer (40),

- 14 (e) removal of at least part of the growth substrate wafer (10) from the semiconductor layer
- 15 stack (1),
- 16 (f) application of a contact layer (2) to the n-conducting semiconductor layer (11),
- 17 (g) separation of the wafer produced in steps (a) to (f) into individual semiconductor chips.

1 25. Method for fabricating a plurality of semiconductor chips which emit electromagnetic
2 radiation, comprising the following method steps:

- 3 (a) provision of a growth substrate wafer (10),
- 4 (b) epitaxial growth of a semiconductor layer sequence (1) on the growth substrate wafer
- 5 (10), which includes a p-conducting semiconductor layer (13), an n-conducting semiconductor
- 6 layer (11) and an electromagnetic radiation generating region (12) which is arranged between
- 7 these two semiconductor layers (11, 13), the n-conducting semiconductor layer (11) being first of
- 8 all grown on the growth substrate wafer (10),
- 9 (c) application of a mirror layer (40) to the surface of the p-conducting semiconductor
- 10 layer (13),
- 11 (d) production or application of a base (50) on or to the mirror layer (40),
- 12 (e) removal of at least part of the growth substrate wafer (10) from the semiconductor layer
- 13 stack (1),
- 14 (ea) etching or mechanical patterning of the exposed n-conducting semiconductor layer (11)
- 15 or of the remaining part of the growth substrate wafer (10), so that a plurality of planar sub-
- 16 surfaces (14), which are positioned obliquely with respect to a main plane of the radiation-
- 17 generating region (12) and each form an angle of between 15° and 70° with this plane, are

18 formed on the n-conducting semiconductor layer surface or on the growth substrate wafer
19 surface,

20 (f) application of a contact layer (2) to the n-conducting semiconductor layer (11),

21 (g) separation of the wafer produced in step a to f into individual semiconductor chips.

1 26. Method according to Claim 24, in which after method step (e) the remaining part of the
2 growth substrate wafer (10) is at least partially patterned for the purpose of electrically
3 contacting the n-conducting semiconductor layer (11).

1 27. Method according to Claim 26, in which before method step (f) the n-conducting
2 semiconductor layer (11) or the remaining part of the growth substrate wafer (10) is patterned by
3 means of an etching process or mechanical patterning in such a way that a plurality of planar
4 sub-surfaces (14), which are positioned obliquely with respect to a main plane of the radiation-
5 generating region (12) and each form an angle of between 15° and 70° with this plane, are
6 formed on the n-conducting semiconductor layer surface or on the growth substrate wafer
7 surface.

1 28. Method according to Claim 24, in which the reflection sub-surfaces (14) and/or the
2 outcoupling sub-surfaces (14) form pyramid-like structures (15).

1 29. Method according to Claim 24, in which the mirror layer (40) is produced with a plurality
2 of layers.

1 30. Method according to Claim 24, in which the mirror layer (40) is produced as a result of
2 - a highly reflective layer (41) being applied to the p-conducting semiconductor layer (13),
3 - a protective layer (42) being applied to the highly reflective layer (41) or, if the latter is
4 not present, to the p-conducting semiconductor layer (13) and/or
5 - a joining layer (43) being applied to the protective layer (42) or, if the latter is not
6 present, to the highly reflective layer (41) or, if the latter is not present, to the p-conducting
7 semiconductor layer (13).

1 31. Method according to Claim 30, in which the highly reflective layer (41), the protective
2 layer (42) and/or the joining layer (43) is/are applied by vapour deposition or sputtering.

1 32. Method according to Claim 24, in which, according to method step (d), the base (50) is
2 soldered or adhesively bonded to the mirror layer (40).

1 33. Method according to Claim 24, in which, before method step (f), at least one trench (17)
2 is patterned in the semiconductor layer stack (1), extending at least through the n-conducting
3 semiconductor layer (11) and the electromagnetic radiation generating region (12) and thereby
4 defining a plurality of individual semiconductor layer elements (18).

1 34. Method according to Claim 33, in which the trench(es) (17) are filled with an electrically
2 insulating material (19) which transmits radiation generated by the radiation-generating region.

- 1 35. Method according to Claim 33, in which the trench(es) (17) are patterned by means of
- 2 photolithography and/or etching.